ORAL DRUG DELIVERY SYSTEM FOR ENHANCING THE BIOAVAILABILITY OF ACTIVE FORM OF GLYCYRRHIZIN

[0001]

The present invention relates to a drug delivery system for oral administration of glycyrrhizin. More particularly, it relates to such a drug delivery system for enhancing the bioavailability of glycyrrhizin.

[0002]

Glycyrrhizin is a naturally occurring substance found in licorice root (*Glycyrrhiza glabra L.*) that has long been used as a Chinese medicine. It has a strong sweet taste and is used as a sweetener. In addition, glycyrrhizin is used in the treatment of chronic hepatitis, allergic disorder and other pathological conditions by its intravenous administration.

[0003]

Chemically glycyrrhizin is a glucuronide of glycyrrhetic acid with two moles of glucuronic acid. Several studies on the pharmacokinetic behavior of glycyrrhizin in human and animals have revealed that glycyrrhizin is scarcely detectable in the blood following oral administration but its hydrolyzed product, glycyrrhetic acid, is detectable in the blood. See, Wang, Z. *et al.,* Biol. Pharm. Bull. 17(10):1390-1403(1994); Yamamura, Y. *et al., ibid.,*

18(2):337-341(1995); and Takeda, S. *et al.,* J. Pharm. Pharmacol. 48:902-905(1996). Accordingly, it has been considered that glycyrrhizin is poorly absorbable from digestive tract as such (active form), and hydrolyzed in the digestive tract into glycyrrhetic acid which is known to have only little therapeutic effect on hepatitis. Since glycyrrhizin is mainly absorbed in this form, its bioavailability is very low.

[0004]

In order to enhance the bioavailability, rectal administration of glycyrrhizin in the form of a rectal suppository was proposes (JP-A-01294619, JP-A-03002122 and JP-A-03123731). Other attempts to enhance absorbability from digestive tract include providing an enteric oral preparation containing a fatty acid glyceride (JP-A-03255037) and an oral preparation containing a lipid emulsion or lipid complex (JP-A-06192107). With these prior art suppository and oral preparations, however, the blood concentration of glycyrrhizin does not reach a level sufficient to exhibit its therapeutic effect.

[0005]

There exists, therefore, a need for a method and device for enhancing the bioavailability of active glycyrrhizin in oral route to a therapeutically effective level.

[0006]

SUMMARY OF THE INVENTION

According to the present invention, the above need may be met by providing a colon-targeted oral drug delivery system comprising an amount of glycyrrhizin capable of selectively releasing the same in the colon at a concentration overwhelming the rate of hydrolysis by the intestinal flora. Preferably, all or a portion of the carrier consists of an absorption promoter to promote the absorption of glycyrrhizin released from the drug delivery system.

[0007]

When glycyrrhizin is formulated into such drug delivery systems (DDS), it is released selectively in the colon at such a high concentration that saturates and overwhelms the rate of hydrolysis by the intestinal flora and, therefore, the majority of glycyrrhizin may be absorbed in the active form from the colon to achieve remarkably improved bioavailability.

[0008]

DETAILED DESCRIPTION OF THE INVENTION

The drug delivery system according to the present invention basically comprises a core portion containing glycyrrhizin in admixture with a pharmaceutically acceptable carrier and a skin or shell portion enclosing the core portion. The core portion may take the form of powders, granules, tablets, pills, supporsitories or liquid

preparations. Glycyrrihizin is released and absorbed selectively in the colon upon rupture or disintegration of the skin or shell portion in the colon.

[0009]

The core portion contains glycyrrhizin in an amount sufficient to compensate for and substantially overwhelm the rate of hydrolysis of glycyrrhizin by the intestinal flora.

[0010]

The term "glycyrrhizin" as used herein includes free glycyrrhizin and a salt thereof such as sodium, potassium or ammonium salt.

[0011]

Preferably all or a portion of the carrier consists of a substance that promotes the absorption of glycyrrhizin. Examples of such absorption promoters include a pharmaceutically acceptable organic acid such as citric, malic, maleic, fumaric or tartaric acid; a surfactant such as sodium lauryl sulfate, polyoxyethylene sorbitan, polyoxyethylene hydrogenated castor oil, polyoxyethylene alkyl ether, polyoxyethylene alkylphenyl ether, deoxycholate or ursodeoxycholate; or a chelating agent such as EDTA.

[0012]

The core portion may be produced by a method similar to those methods well known in the art for preparing oral solid preparations. It has been known in the art that the

transit time of unit dosage forms for oral administration through the small intestine after expulsion from the stomach and before arrival at the large intestine (small intestine-transit time) is at around 3-4 hours whereas the time required for expulsion of such dosage forms from the stomach after administration may vary to a large extent. It is also known that a distinct rise in pH in the digestive tracts from around 1-3 in the stomach to around 6-7 in the small intestine. The colon-targeting DDS according to the present invention may be designed on the basis of these known physiological phenomenon. Now the colon-targeting DDS of the present invention will be described in detail.

[0013]

1. Unit dosage forms similar to rectal suppositories encapsulated in anionic polymer capsules

[0014]

As noted above, the transit time of solid unit dosage forms such as tablets or capsules through the small intestine is relatively constant at around 3-4 hours. Accordingly, the anionic polymer capsules are designed to have a wall thickness to be dissolved out within the small intestine-transit time to allow the disintegration of the core portion in the lower part of the small intestine for releasing the drug. The wall thickness may routinely be determined empirically through a series of *in vitro* test.

[0015]

Examples of commercially available anionic (enteric) polymers from which the capsule is made include Eudrgid™ S-100 (methacryl acid-methyl methacrylate copolymer), Eudragit™ anionic polymer 4135F (methacrylic acid-methyl acrylate-methyl methacrylate copolymer) and the like.

[0016]

Since glycylrrhizin must be released in the large intestine at higher concentrations as noted above, unit dosage forms similar to rectal suppositories are well suited as a capsule content for this purpose. The method for preparing such unit dosage forms is well known in the art and comprises the steps of adding glycyrrhizin to a suitable suppository base such as Witepsol™ H15 (higher fatty acid di- and triglycerides available from Dynamit Nobel) while being in molten state to make a suspension, casting the suspension into a mold and then cooling the mold to solidify the suspension. The resulting suppository-like dosage forms are placed in the above-mentioned capsules and the capsule seams are sealed with an adhesive of the same anionic polymer. Alternatively, the suppository-like dosage forms may be encapsulated by forming a coating film of the anionic polymer on the surfaces thereof by the dipping method.

[0017]

2. Time controlled capsule preparations which have an

enteric coating and release the drug in time corresponding to the small intestine transit time after expulsion from the stomach

[0018]

The capsules of this type are known as "colon targeted delivery capsule (CTDC)". See, e.g., Takahashi, Journal of Medicine, Vol. 34, S-1, 237-242 (1998). The pharmaceutical feature of CTDC resides in the fact that a drug is present in a conventional gelatin hard capsule together with a pH adjusting organic acid and the capsule has a multi-layer coating consisting of gastric juice-soluble film layer, water soluble film layer and enteric coating layer. Coated capsule preparations designed for releasing the drug in the lower part of digestive tract disclosed in JP-A-09087169 also fall in this class.

[0019]

In the present invention, a pharmaceutically acceptable, solid organic acid such as citric, malic, maleic, fumaric or tartaric acid is used for pH adjusting purpose.

[0020]

3. Use of Pulsinecap™

[0021]

This method is disclosed by C.G.Wilson *et al.,* in Drug Delivery, 4:201-206 (1997).

[0022]

This colon targeted drug delivery system employs capsule bodies made of a water insoluble material such as low-density polyethylene and conventional gelatin capsule caps. The capsule body is filled with the drug in admixture with an excipient or carrier leaving an open space for placing a plug therein. Then a plug made of water-swellable hydrogels such as crosslinked polyethylene glycol is fitted in the opening to seal the capsule body at the neck thereof. Finally the gelatin cap is fitted over the capsule body and the seam is sealed with a suitable coating solution.

[0023]

On ingestion, the gelatin cap dissolves in the gastric juice and capsule body with exposed plug is allowed to pass from the stomach to the small intestin where the hydrogel plug expands in volume progressively by hydration. At a predetermined time point, the expanded plug is ejected from the neck of capsule body and the capsule content is released to the digestive tract. The time at which the plug is ejected may be controlled as desired by adjusting the dimension and the size thereof.

[0024]

4. <u>Use of coating films or capsules made of biodegradable polymers</u>

[0025]

It is known that the microorganism flora found in the

large intestine produces an enzyme which reduces and cleaves azo-linking groups. Accordingly, polymers containing azo-linking groups (azo polymers) are specifically degraded (depolymerized) in the large intestine. Based on this phenomenom, a colon-targeted DDS may be designed by coating tablets with the azo polymer or encapsulating a drug in a capsule made of the azo polymer.

[0026]

A variety of azo polymers have been known and a typical example thereof is styrene-hydroxyethyl methacrylate-divinyl azobenzene copolymer. Other colon-degradable polymers are known and include a polyester polymer which is co-polyester of terephthalic acid with cellobiose and polytetramethylene glycol (CTPT polymer) published by Takada *et al.,* in Pham. Tech Japan, Vol. 11(11), 37(1995).

[0027]

5. Use of time-controlled, colon-targeted delivery capsules

[0028]

This system is disclosed in U.S. Patent No. 5,637,319 to Kanji Takada. Briefly, the system utilizes capsules made of ethylcellulose. The capsule contains the drug and a water swellable substance. When administered, the capsule ruptures after elapsing a time at which sufficient force is exerted on the capsule wall to rupture the capsule and

release the drug as the water swellable substance swells.

[0029]

Examples of water swellable substances include low substitution-degree hydroxypropylcellulose, CMC sodium and CMC calcium. The swellable substance is compressed into a suitable shape such as tablet that fits within the capsule at a suitable location. The drug, glycyrrhizin in this case, is placed as a mixture with a pharmaceutical excipient or carrier in the remaining space within the capsule. A number of microholes are defined through the capsule wall in the area facing the shaped swellable substance. Except these microholes, the capsule is sealed.

[0030]

When administered orally, water will enter inside the capsule through the microholes and swell the swellable substance to exert a pressure on the capsule wall for a time until the contained drug is released by the rupture of the capsule. The rupturing time of the capsule may be controlled for the colon targeted delivery by adequately selecting the number and diameter of microholes, the capsule wall thickness, the type and size of water swellable substance.

[0031]

6. Use of Internal pressure-collapsible, colon-targeted delivery capsules

[0032]

This system is also disclosed in U.S. Patent No. 5,637,319 to Takada and Seizai-to-Kikai (Pharmaceutical preparations and machines), January 15, 1998 issue.

[0033]

This capsule is collapsed in the colon as follows. Ingested diet is flowable in the stomach and small intestine because of abundant presence of water-containing digestive juice whereas the content in the large intestine becomes highly viscous since reabsorption of water and formation of stool take place there. In such a dense environment, the capsule will rupture by the internal pressure associated with the peristalsis of colon to release the drug contained therein.

[0034]

The capsule is made of ethylcellulose or gelatin lined with ethylcellulose inside. Since the capsule content must be a liquid form when the capsule is collapsed, glycyrrhizin is contained in the capsule as a solution or dispersion in propylene glycol, polyethyleneglycol or vegetable oils, or dispersed in a base for making rectal suppositories which liquify at the body temperature. The rupture time in the colon may be controlled by varying the wall thickness of the ethylcellulose capsule.

[0035]

All patents, patent applications and publications cited

above are incorporated herein by reference.

[0036]

Indications of the glycylrrhizin preparation of the present invention include hepatic dysfunction in chronic hepatic disease, various eczema, drug rush, stomatitis, infant strophulus, phlyctena, alopecia areata and the like. The dose of the glycyrrhizin preparation of the present invention may be determined depending on the age, body weight, the type and severity of disease of a particular patient. The daily dose for adult patients (60kg of body weight) with chronic hepatic disease ranges between 10mg and 1,000mg, preferably between 100mg and 800mg as glycyrrhizin. This dose may be administered at once or divided twice or more.

[0037]

EXAMPLE

The invention will be described in detail by making reference to the following non-limiting examples.

[0038]

Example 1

100mg of glycyrrhizin sodium salt and 100mg of HCO-60 (polyoxyethylene hydrogenated castor oil) were dissolved in 0.5 ml of propylene glycol. A colon-targeted delivery capsule of the intra-colon pressure collapsible type (gelatin capsule having inner ethylcellulose lining) was produced by

filling the capsule with the above solution.

[0039]

Example 2

100mg of glycyrrhizin potassium salt was dispersed in 400mg of molten Witepsol™ H15 (higher fatty acid di- and triglyceride) heated at 50℃. The dispersion was poured into a mold and then cooled well to 6℃ to obtain a solid article having supository-like shape. This shaped article was dusted with fine talcum powder and then coated with ethylcellulose film by the dipping method to thereby obtain a intra-colon pressure collapsible, colon-targeted delivery capsule.

[0040]

Example 3

Pulsincap™ (available from Scherer DDS Ltd., UK) was filled with 100mg/capsule of glycyrrhizin.

[0041]

Example 4

A tablet containing 100mg of glycyrrhizin was produced by the conventional method. The tablet was coated with a colon-degradable CTPT polymer film to obtain colon-targeted DDS.

[0042]

<u>In vivo bioavailability test</u>

Method:

The test preparation was orally administered with 50ml of water to adult beagle dogs having been fasted overnight for 12 hours. After administration, 2ml of blood samples were collected periodically over 24 hours from the jugular vein and assayed for plasma glycyrrhizin levels using HPLC. Commercial glycylrrhizin tablets (Glycyron™) were used as a control drug. The dose was 100mg as glycyrrhizin.

[0043]

Results:

	Plasma glycyrrhizin level (μ g/ml) Time after administration (hr.)				
	1	2	3	4	5
Glycyron tab.	ND*	ND	ND	ND	ND
Preparation of Ex.2	ND	ND	0.7	4.8	5.9

	Plasma glycyrrhizin level (μ g/ml) Time after administration (hr.)			
	6	8	10	24
Glycyron tab.	ND	ND	ND	ND
Preparation of Ex.2	4.7	3.7	3.1	2.9

* Not detected.

[0044]

As shown in the above table, glycyrrhizin was not

detected in the plasma after oral administration of commercial glycyrrhizin tables. In contrast, when the colon-targeted DDS capsule of Example 2 was orally administered, the plasma glycyrrhizin level began to rise 3 hours after the administration, reached a peak in 4-5 hours and remained at a therapeutically effective level at least up to 24 hours after the administration.